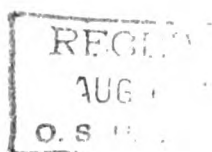


UNITED STATES BUREAU OF MINES
SCOTT TURNER, DIRECTOR

INFORMATION CIRCULAR

SUMMARY OF ORE-MINING COST DATA



BY

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INFORMATION CIRCULAR
UNITED STATES BUREAU OF MINES

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By Chas. F. Jackson²

INTRODUCTION

During the past 5 years the Bureau of Mines has published information circulars dealing with mining methods and costs at 78 ore mines; 7 circulars, each of which is devoted to a discussion of one of the principal mining methods; and 23 circulars dealing with special phases of mining, such as ventilation, shaft sinking, tunnel driving, the cost of equipping and developing prospects and small mines, underground transportation, diamond drilling, and ground support.

These circulars were written by many different authors, and in order that the method of presentation and the basis for compilation of data might be the same in all the papers the Bureau drafted an outline to be followed in their preparation. To clarify the data in these circulars, which are in the libraries of many engineers and mining companies, and the summarized data presented in this paper, that portion of the outline dealing with cost and labor-performance data is reproduced below.

The authors of papers dealing with individual mines have not in all instances been able to adhere strictly to the method of cost distribution set forth in the outline because their cost-accounting systems did not yield the necessary figures. On the whole, however, the basis employed in each paper conforms fairly closely to that of the outline.

In the following pages cost data are included from a number of mines not covered by Bureau of Mines circulars, and in such cases the source of the data is indicated by footnotes.

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- ¹ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6785."
 - ² Principal mining engineer, U. S. Bureau of Mines.

TABLE A. - Summary of costs8777.0 .1
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Name or number of mine.....Period covered.....

Tons ore hoisted during period.....

Mining method (if more than one method is used, give data for each method separately).....

1. Underground costs per ton of ore hoisted:

	1 Labor	2 Super- vision	3 Compressed air, drills, and steel	4 Power cost	5 Explos- ives	6 Timber	7 Other sup- plies	8 Total
Development (1) In ore (2) In rock								
Mining								
Transportation (underground)								
General under- ground expense								
Surface expense (Directly appli- cable to under- ground operation)								
Total								

NOTES:

General: Since in some methods of stoping, notably shrinkage, there are periods when the tons hoisted may vary considerably from the tons broken, it is desirable to select a period during which these tonnages are practically equal. Where this cannot be done, mining costs should be based upon the tons of ore broken rather than the tons hoisted, and a note should be made so stating. Also, where the period includes an abnormal amount of development (either high or low), note should be made of this fact. The intent of the reports is to give a true statement of costs under various conditions and for different methods of mining and practice, and it would be desirable to point out briefly in what respects, if any, the period covered by cost figures fails to accomplish this.

1. "Labor for development" includes all miners, shovelers, and timbermen employed in shaft sinking, constructing shaft stations and pockets, and driving drifts, crosscuts, raises, and winzes.

"Mining labor" includes all labor employed in stopes up to the delivery of the ore to the haulage system. Miners, shovelers, timbermen, blasters, tool nippers, scraper operators, etc., employed in stopes would be included.

Where bulldozing, blockholing, filling, or scaling are major operations, these costs should be entered as separate items under the general caption "Mining."

Under "Haulage" include costs of hand trammers, locomotive crews, chute tappers, pocketmen and hoisting engineers engaged in haulage of ore and rock and the delivering of same to surface, the cost entered being based on the tons of ore hoisted. Where scrapers are used as a part of the haulage system on the levels, the cost of their operation should be entered under Haulage.

2. "Supervision" includes salaries and wages of foremen, shift bosses, engineers, and superintendent properly chargeable to underground operations.

3. "Compressed air, drills, and steel" covers costs of operating compressors, including power therefor, rock-drill repairs, steel sharpening and consumption, and installation of air and water lines.

4. Power cost includes power for haulage and hoisting, shovels and scrapers, fan operation, etc., but does not include power for air compressors, which should be entered under 3.

5. Explosives used are charged to development and mining, respectively, the "total" figure being total cost of explosives, divided by tons of ore hoisted during the period or by tons ore and rock broken in special cases as outlined above. In the latter case, figures should be explained by a footnote.

TABLE B. - Summary of costs in units of labor, power, and supplies

Name or number of mine.....Period covered.....

Tons ore mined and hoisted.....

Mining method (if more than one method is used, give tonnages and data for each method separately).....

	Development	Mining (stoping)	Total
A. <u>Labor (man-hours per ton)</u>			
Breaking (drilling and blasting)			
Timbering (or) (and) filling			
Shoveling			
Haulage and hoisting			
Supervision			
General			
Total labor underground			
Ave. tons per man-shift			
Labor, percent of total cost			
Ave. tons per man-shift on surface properly chargeable to underground operation.			
B. <u>Power and supplies</u>			
Explosives (lbs. per ton) (kind and grade)			
Timber (b.m. - lin. ft. or cu. ft.)			
Total power (kw. - hr. or hp. - hr. per ton)			
(1) Air compression			
(2) Hoisting			
(3) Pumping			
(4) Ventilation			
(5) Lighting			
Other supplies in percentage of total supplies and power.			
Supplies and power, percent of total cost			
C. <u>Percent of total cost</u>			

NOTE: Where the mining method is such that bulldozing, filling, undercutting, drawing, scaling down, etc., are of major importance it is desirable that the costs of these items be tabulated separately under the general caption "Mining". Where records do not give a separation between development and mining as, for instance, would be the common case for "haulage and hoisting", give only total cost. The notes under table A covering distribution of costs apply also to table B.

SUMMARY OF TOTAL DIRECT MINING COSTS BY STOPPING METHODS

The first cost summaries will be grouped according to the principal stopping method employed; that is, mines employing open stopes will be grouped together in one table, those employing shrinkage stopping in another table, etc. In some mines two methods of stopping are employed about equally, and in others as many as 4 or 5 different methods are employed, so that no hard and fast line can be drawn in making the groupings. Also, opinions among engineers differ as to the proper designation of the stopping system at certain mines, and therefore the grouping employed here may not accord with the opinions of all readers.

Open Stopping

Open stopes are defined here as supported stopes in which no artificial support, such as systematic timbering, ore, or waste filling, is employed to support the back or walls of the stope other than occasional props, stulls, or cribs to hold local patches of bad ground temporarily.

Table 1 gives mining costs at a number of open-stope mines, distributed as between development, stopping, underground transportation, general underground expense, and surface expense directly applicable to underground work.

In table 2 the costs of substantially the same group of mines are distributed between labor and supervision; compressed air, drills, and steel; power; explosives; and other supplies.

TABLE 1. - Mining costs at open-stope mines

Designation and year	Variation of open- stope method	Cost per ton of ore hoisted					Total
		Develop- ment	Stoping	Transpor- tation, under- ground	General under- ground	Surface applic- able to under- ground	
1. Mineville, N. Y., 1927	With irregu- lar pillars	\$0.103	\$0.416	\$0.705	\$0.026	---	<u>1/</u> \$1.250
2. Marquette, No. 1, 1928	Regular pil- lars, breast and bench mining	.218	.770	.244	.180	---	<u>1/</u> 1.412
3. Marquette, No. 2, 1928	Sublevel stoping	.251	.707	.149	.193	.066	<u>1/</u> 1.366
4. Menominee, No. 1, 1928	do.	.211	.467	.173	.052	.027	<u>1/</u> .930
5. Hanover- Bessemer, 1929	Underhand benching to inclined- stope raises	?	<u>1/</u> .343	<u>1/</u> .187	?	?	?
6. Burra-Burra, 1923	Sublevel stoping	<u>2/</u> .229	.332	.386	.145	.043	1.135
7. Mary, 1928	Regular stope and pillar, underhand benching	.355	.545	<u>3/</u> .714	.154	.060	1.828
8. Ducktown No. 3, 1928	do.	.302	.271	<u>3/</u> .366	.076	.015	1.030
9. No. 8 mine, S. E. Mo., 1928	With irregu- lar pillars	.045	.483	.222	.135	---	.885
10. Tri-State No. 1, 1928	do.	.049	.532	.217	.187	---	.985
11. Tri-State No. 2, 1928	do.	.050	.458	.200	.235	---	.993
12. Tri-State No. 3, 1928	do.	.030	.450	.165	.162	.194	1.001
13. Waco, Tri-State, 1927-28	do.	.050	.490	.155	.057	.033	.785
14. Barr, Tri- State, 1929	With irregu- lar pillars	.047	.497	.217	.069	.032	.862
15. Hartley- Grantham, 1929	do.	.000	.516	.196	.049	.020	.781

TABLE 1. - Mining costs at open-stone mines (continued)

Designation and year	Variation of open- stope method	Cost per ton of ore hoisted					Total
		Develop- ment	Stoping	Transpor- tation, under- ground	General under- ground	Surface applic- able to under- ground	
16. Hartley, 1932	With irregu- lar pillars	\$0.000	\$0.572	\$0.152	\$0.063	\$0.041	\$0.828
17. Michigan Copper B, 1927	Regular pil- lars, large stopes	.197	.600	.418	.057	.022	1.294
18. Michigan Copper C, 1927	Regular pil- lars, long, narrow stopes	.379	.500	.596	.075	.004	1.554
19. Mascot, 1929	Milling, irregular pillars	.053	.222	.278	.086	---	.639
20. Montreal, 1928	Sublevel stoping	.461	.255	.278	.106	.060	1.160
21. Spring Hill, 1929-30	Modified sublevel stoping	.377	1.072	.131	.218	.147	1.945
22. Rifle, colo., 1931	Regular stope and pillar	.200	1.350	.240	.090	.080	1.960
23. Granada, Quebec, 1932	Simple open stopes, no pillars	1.163	2.765	.974	.111	---	5.013
24. Sherritt- Gordon, 1931-32	Underhand benching or subleveling, with high lift	.327	.746	.231	---	---	1.304
25. Presidio, Tex., 1929	Irregular pillars	1.065	2.276	.533	---	.127	4.001
26. El Potosi, August, 1933	Open, under- hand stopes with pillars	.202	.337	.100	.067	.143	.849

1 Mines 1 to 5, inclusive, are iron mines, and costs are computed on a long-ton (2,240 pounds) basis; all other mines on short-ton basis.

2 Development greatly exceeds ore-extraction rate.

3 Includes hand shoveling.

References to designations:

(1) I.C. 6092, (2) I.C. 6138, (3) I.C. 6179, (4) I.C. 6180, (5) I.C. 6361, (6) I.C. 6149, (7) I.C. 6397, (8) special communication, (9) I.C. 6160, (10) I.C. 6113, (11) I.C. 6121, (12) I.C. 6174, (13) I.C. 6150, (14) I.C. 6159, (15) I.C. 6286, (16) I.C. 6656, (17) Bull. 306, (18) Bull. 306, (19) I.C. 6239, (20) I.C. 6369, (21) I.C. 6402, (22) I.C. 6662, (23) I.C. 6709, (24) Canadian Inst. Min. and Met. Bull. 257, September, 1933. (25) Am. Inst. Min. and Met. Eng., General Volume, 1931. (26) I.C. , manuscript in press.

TABLE 2. - Mining costs at open-stope mines

Designation and year	Cost per ton of ore hoisted					
	Labor and super- vision	Compressed air, drills, and steel	Power	Explo- sives	Other supplies	Total
1. Mineville, N. Y., 1927	\$0.755	\$0.155	\$0.087	\$0.143	\$0.110	<u>1/</u> \$1.250
2. Marquette No. 1, 1928	.893	.153	.108	.136	.122	<u>1/</u> 1.412
3. Marquette No. 2, 1928	.781	.092	.141	.093	.259	<u>1/</u> 1.366
4. Menominee No. 1, 1928	.562	.111	.070	.129	.058	<u>1/</u> .930
6. Burra-Burra, 1928	.744	.088	.035	.126	.142	1.135
7. Mary, 1928	1.169	.231	.216	.142	.070	1.828
8. Ducktown No. 3, 1928	.675	.090	.051	.111	.103	1.030
9. No. 8 Mine, S. E. Missouri, 1928	.642	.081	.046	.077	.039	.885
10. Tri-State No. 1, 1928	.624	.127	.041	.110	.083	.985
11. Tri-State No. 2, 1928	.576	.114	.076	.157	.070	.993
12. Tri-State No. 3, 1928	.675	.075	.102	.117	.032	1.001
13. Waco, 1927-28	.536	---	.109	.072	.068	.785
14. Barr, 1929	.529	.066	.048	.103	.116	.862
15. Hartley-Grantham, 1929	.535	.052	.036	.107	.051	.781
16. Hartley, 1932	.507	.078	.060	.150	.033	.828
19. Mascot, 1929	.454	.047	.016	.060	.062	.639
20. Montreal, 1928	.698	.107	.106	.136	.113	<u>1/</u> 1.160
21. Spring Hill, 1929-30	1.415	.183	.003	.267	.077	1.945
22. Rifle, Colo., 1931	1.290	.100	.150	.240	.180	1.960
23. Granada, 1932	2.982	.730	.076	1.024	.201	5.013
24. Sherriitt-Gordon, 1931-32	<u>2/</u> .685	<u>2/</u> .210	<u>2/</u> .015	<u>2/</u> .272	<u>2/</u> .122	1.304
25. Presidio, 1929	2.859	.597	.049	.294	.202	4.001
26. El Potosi, 1933	.357	.035	.148	.082	.084	.706
Undistributed general surface expense...						.143
Total						.849

1/ Per long ton of 2,240 pounds.2/ Distribution estimated from original paper.

Shrinkage Stopping

Shrinkage stopping is that method in which the stopes are worked from the bottom up in successive slices, the stope being kept full of broken ore upon which the miners stand in advancing the stopes upward, and only enough ore is drawn after each slice is broken to provide working room between the back and the pile of broken ore. The broken ore left in the stope also provides some measure of support to the walls during stopping and is drawn off when the stope has been completed. There are a number of variations of this method, some of which are quite distinct, and their inclusion under shrinkage stopping may be open to some question. Thus, in the method employed at the Alaska-Juneau the backs are broken by large blasts following which considerable ore often caves, and while drilling and blasting the miners do not work from the top of the broken-ore pile, but from raises communicating to a higher level. In this circular, however, such methods are included under shrinkage stopping, since the stope is kept wholly or partly filled with broken ore.

Table 3 presents mining costs at a number of mines employing shrinkage stopping or variations thereof, the costs being distributed between development, stopping, underground transportation, general underground expense, and surface expense directly applicable to underground work. Table 4 shows these costs distributed between labor and supervision; compressed air, drills, and steel; power; explosives; timber; and other supplies.

**TABLE 3. - Mining costs at mines employing shrinkage
stoping or variations thereof**

Designation and year	Variation of shrinkage method	Cost per ton of ore hoisted					Total
		Develop- ment	Stoping	Under- ground transportation	General under- ground	Surface applic- able to under- ground	
27. Harmony, Idaho, 1929	Simple shrink- age, on drift pillars	\$0.750	\$2.050	\$0.210	\$0.230	---	\$3.240
28. Nevada- Massachu- setts, 1928	do.	.907	2.743	Included with de- velopment and stoping	.105	---	3.755
29. Hillside, 1929	On pillars or on stulls	.383	1.276	.399	.404	\$0.138	2.600
30. Daisy, 1929	On stulls	1.165	1.395	.816	.340	.150	3.866
31. Cortez, 1929	On drift pillars	1.427	1.972	.467	---	---	3.866
32. Eighty-Five, August, 1930	On pillars or on stulls	1.000	1.970	1.280	1.240	---	5.490
33. Verde Cen- tral, 1929- 1930	On stulls	?	1.661	.580	.111	.033	<u>1/</u> 2.385
34. Teck-Hughes, 1929	On drift pillars	.433	1.557	.443	.202	.435	3.070
35. Kirkland Lake Gold, 1930	On drift timbers	2.870	1.620	1.610	.140	.520	6.760
36. Elko, 1930	On stulls	1.298	1.610	.416	.443	.257	4.024
37. Mogollon, N. Mex., 1922	On drift pillars	.883	1.728	1.178	.096	.045	3.930
38. Sylvanite, 1930	On stulls	1.229	2.218	.641	.397	---	4.585
39. Engels, 1928	On drift pillars	.479	.760	.438	---	---	1.677
40. Mt. Hope, N.J., 1930	On drift and slope pillars	.104	.632	.459	.111	.113	<u>2/</u> 1.419
41. Vipond, 1930	On stulls or drift pillars	.728	1.275	.629	.148	---	2.780
42. Beatson, 1922-26	Large blasts from mining raises	<u>3/</u> .290	.366	.137	---	---	.793
43. Alaska- Juneau, 1928	Coyote blast- ing from mining raises	.061	.122	.114	---	---	.297

See next page for footnotes.

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- 1/ Includes stope development but not general development.
 2/ Iron ore, costs based on long-ton unit (2,240 pounds).
 3/ Includes \$0.237 for stope preparation and development.

References to designations:

- (27) I.C. 2640, (28) I.C. 6284, (29) I.C. 6294, (30) I.C. 6384, (31) I.C. 6327,
 (32) I.C. 6413, (33) I.C. 6464, (34) I.C. 6322, (35) I.C. 6490, (36) I.C. 6543,
 (37) Trans. Am. Inst. Min. and Met. Eng., vol. 72, 1925, pp. 529-549,
 (38) Special communication, (39) I.C. 6260, (40) I.C. 6601, (41) I.C. 6525,
 (42) Trans. Am. Inst. Min. and Met. Eng., vol. 76, 1928, pp. 11-55,
 (43) I.C. 6186.

TABLE 4. - Mining costs at mines employing shrinkage
 stoping or variations thereof

Designation and year	Costs per ton of ore hoisted						Total
	Labor and super- vision	Compressed air, drills, and steel	Power	Explo- sives	Timber	Other supplies	
27. Harmony, Idaho, 1929	\$1.770	\$0.300	\$0.220	\$0.360	\$0.230	\$0.360	\$3.240
28. Nevada-Massachu- setts, 1928	2.345	.125	.301	.455	.182	.347	3.755
29. Hillside, 1929	1.824	.144	.138	.301	.082	.111	2.600
30. Daisy, 1929	2.679	.352	.140	.370	.120	.205	3.866
31. Cortez, 1929	2.445	.430	.116	.495	.090	.290	3.866
34. Teck-Hughes, 1929	2.021	.152	.284	.407	.047	.159	3.070
35. Kirkland Lake Gold, 1930	4.160	.610	.390	.850	.450	.300	6.760
36. Elgoro, 1930	2.667	.189	.167	.355	.214	.432	4.024
37. Mogollon, N. Mex., 1922	2.365	---	.457	all supplies		1.108	3.930
38. Sylvanite, 1930	2.621	.721	.202	.733	.128	.180	4.585
39. Engels, 1928	1.098	.189	---	.267	.032	.091	1.677
40. Mt. Hope, N. J., 1930	.729	.227	.165	.141	.027	.130	1.419
41. Vipond, 1930	1.703	.378	.091	.331	.046	.231	2.780
42. Beatson, 1922-26	.347	.119	---	.140	---	.187	.793
43. Alaska-Juneau, 1928	.1803	---	.0089	.0594	---	.0480	.2966

Cut-and-Fill Stopping

In cut-and-fill stopping the ore is stoped upward from the level in a series of horizontal or inclined slices, and after each slice is taken the empty space is filled to within a few feet of the back with waste rock, sand or gravel, or mill tailings. A regular cycle of operations is followed, that is, drilling and blasting the slice, removal of the broken ore, filling, drilling and blasting again, and so on. Resuing is a variation of this method of stoping and is sometimes employed for mining narrow veins of less than stoping width. In resuing, either the ore is blasted first and then enough wall rock taken down to make room for working and to fill the stope to within a few feet of the back, or the wall is blasted first and the ore then stripped off. In ordinary cut-and-fill stopes little timber is employed, except for temporary stulls and cribs to support local patches of insecure ground, and for timbering ore passes through the fill. In the stringer-set-and-fill system, however, a regular system of stull timbering is employed to support the walls pending introduction of the fill. This system is employed at the Hecla and Morning mines in the Coeur d'Alene district of Idaho and is considered by some to be a variation of the square-set stopping system.³ Since the timbering is not in the form of framed rectangular or square sets and the sequence of operations is the same as in cut-and-fill stoping the author prefers to consider the stringer-set-and-fill system a variation of cut-and-fill stoping.

In cut-and-fill stoping considerable waste often is sorted from the broken ore, and this usually increases the cost of stoping per ton considerably, though it may and often does result in a lower cost per unit of metal recovered.

In table 5 direct mining costs are given for a number of mines employing cut-and-fill stoping as the principal stoping method, the costs being distributed between development, stoping, underground transportation, general underground expense, and surface expense directly applicable to underground operations. In table 6 these costs are distributed between labor and supervision; compressed air, drills, and steel; power; explosives; timber; and other supplies.

³ Gardner, E. D., and Vanderburg, William O., Square-Set System of Mining: Inf. Circ. 6691, Bureau of Mines, 1933, 73 pp.

TABLE 5. - Mining costs at mines employing cut-and-fill stopping

Designation and year	Variation of cut-and-fill stopping	Cost per ton of ore hoisted					Total
		Develop- ment	Stoping	Transpor- tation, under- ground	General under- ground	Surface applic- able to under- ground	
44. Questa Molybdenum, 1929-30	Horizontal, largely resuing	\$6.10	\$5.51	(Included under develop- ment and stopping)			\$11.61
45. Cold Springs, 1/ 1931	Resuing	6.573	35.951	1.051	3.597	----	17.172
3/ do.	do.	1.010	.914	.161	.552	----	2.637
46. Lucky Tiger, Sonora, 1924	Resuing, with rills in wide ore	2.900	5.740	1.410	.720	.370	11.140
47. Matahambre, Cuba, 1928	Horizontal	.711	1.267	.388	.184	.019	2.569
48. Teziutlan, Mex., 1930	Horizontal, with some op- en stones	.926	1.571	.269	.312	.160	3.238
49. United Eastern, 1917-25	Horizontal	.518	42.923	.275 (hoisting only)	.626	----	4.342
50. Champion-1927 do. 1930	Horizontal. Sublevel, inclined	.598 .489	41.765 1.162	5/.158 .552	.180 .207	.020 .112	2.721 2.522
51. Pilares, 1929	Horizontal and inclined	.399	1.370	.370	.250	.211	2.600
52. La Colorada, 1929	6/Horizontal and inclined be- tween stope pillars	.561	1.203	.166	.278	.233	2.441
53. Magma, 1928	Timbered rill, and rill and pillar	.736	2.849	.616	1.166	.130	5.497
54. Morning, 1928	Stringer-set and fill	.442	2.371	.530	.698	.204	4.245
55. Hecla and Star, 1928	do.	.638	1.211	.322	.766	.360	3.297
56. Ground Hog, 1930 7/	Inclined cut- and-fill and square setting	1.393	1.762	.628	.080	.127	3.990
57. McIntyre, 1931	8/50 percent cut-and-fill	.655	1.489	.135	.660	.134	3.073
58. Silver King Coalition, 1929	Stringer sets, stulls, and filling	2.086	3.502	1.848	.309	----	7.745

- 1/ Based on tons of sorted ore hoisted; includes compensation insurance.
- 2/ Includes sorting, \$1.92.
- 3/ Based on tons of crude ore broken.
- 4/ Includes tramping cost.
- 5/ Hoisting only.
- 6/ 54 percent cut-and-fill stoping, 12 percent square setting, 14 percent shrinkage stoping, 20 percent development ore.
- 7/ Listed also under square-set stoping, tables 7 and 8.
- 8/ 50 percent horizontal cut-and-fill; balance shrinkage and square-set stoping.

References:

(44) I.C. 6514, (45) I. C. 6673, (46) Trans. Am. Inst. Min. and Met. Eng., vol. 72, 1925, pp. 468-484, (47) I. C. 6145, (48) I. C. 6736, (49) Trans. Am. Inst. Min. and Met. Eng., vol. 76, 1928, pp. 56-92, (50) Bull. 306, (51) I. C. 6307, (52) I. C. 6247, (53) I. C. 6168, (54) I. C. 6238, (55) I. C. 6232, (56) I. C. 6377, (57) I. C. 6741, (58) I. C. 6371.

TABLE 6. - Mining costs at mines employing cut-and-fill stoping

Designation and year	Costs per ton of ore hoisted						
	Labor and supervision	Compressed air, drills, and steel	Power	Explosives	Timber	Other supplies	Total
44. Questa Molybdenum, 1929-30	\$8.980	All materials and supplies				\$2.630	\$11.610
45. Cold Springs, 1931	1/10.826	1/\$1.555	1/\$1.848	1/.806	1/\$1.172	1/.965	1/17.172
do.	2/ 1.663	2/ .239	2/ .284	2/.123	2/ .180	2/.148	2/2.637
46. Lucky Tiger, Sonora, 1924	6.937	.935	.668	.910	.953	.737	11.140
47. Matahambre, Cuba, 1928	1.588	.161	.087	.200	.269	.264	2.569
48. Teciutlan, Mexico, 1930-31	1.912	.387	.086	.335	.175	.343	3.238
49. United Eastern, 1917-25	2.611	Included in other items (Add miscellaneous)	.287	.513	.462	.302	4.175
						Total	.167 4.342
50. Champion, 1927	1.877	---	.191	All supplies	.653		2.721
do. 1930	1.751	.197	.192	.172	.109	.101	2.522
51. Pilares, 1929	1.593	.231	.055	.232	.319	.170	2.600
52. La Colorada, 1929	1.273	.235	.070	.278	.257	.328	2.441
53. Magma, 1928	3.654	.326	.197	.209	.532	.579	5.497
54. Morning, 1928	3.088	.122	.211	.158	.417	.249	4.245
55. Hecla and Star, 1928	3/ 1.868	.070	.145	.112	.357	.317	2.869
	(Plus development in waste, not segregated)						.428 3.297
56. Ground Hog, 1930	2.793	.169	.179	.187	.318	.344	3.990
57. McIntyre, 1931	1.938	.052	.176	.309	.240	.358	3.073
58. Silver King Coalition, 1929	5.418	.854	.370	.486	.340	.277	7.745

1/ Based on tons of sorted ore hoisted.

2/ Based on tons of crude ore broken.

3/ Except development in waste.

Square-Set Stopping

In square-set stopping the walls and back of the stope are supported by a framework of timbers forming a connected series of hollow, rectangular prisms in the space formerly occupied by the ore and providing continuous lines of support in three directions at right angles to each other; the ore is excavated in a series of small units comprising rectangular blocks just large enough to provide room for standing a set of timber. The ends of the three timber members comprising a set are framed to give each a bearing against the other two at the corners of the sets. The stopes usually are mined upward from the level in horizontal slices or panels but frequently are mined by stepped inclined faces or vertical slices and may also be mined from the top downward. Square-set stopping seldom is employed today, except where the ground is so heavy that the stopes must be filled with waste soon after the sets are placed to provide the necessary support. Square-set stopping frequently is used in conjunction with other stopping methods for mining pillars between caved or filled stopes or for extraction of ore in sections of other types of stopes where additional support is required.

Table 7 gives direct mining costs for a number of mines employing square-set stopping as the principal method, the costs being distributed between development, stopping, underground transportation, general underground expense, and surface expense applicable to underground. In table 8 the costs are distributed between labor and supervision; compressed air, drills, and steel; power; explosives; timber; and other supplies.

TABLE 7. - Mining costs at mines employing square-set stoping
as the principal method

Designation and year	Variation of square-set method	Costs per ton of ore hoisted					
		Develop- ment	Stoping	Transpor- tation, under- ground	General under- ground	Surface applic- able to under- ground	Total
56. Ground Hog	1/ Inclined backs, both square-set- ting and cut- and-fill stoping	\$1.393	\$1.762	\$0.628	\$0.080	\$0.127	\$3.990
59. Argonaut, 1929	Horizontal floors	.165	2.439	.519	.577	.291	3.991
60. Page, 1928	do.	1.170	2.150	.160	.180	.160	3.820
61. Park-Utah, 1928	Inclined backs or rills	.828	2.426	.282	.583	.543	4.662
62. Tintic Standard, 1929	Vertical sections	1.143	4.973	1.056	.424	~~3~~ 1.036	~~2~~ 8.632
63. Bunker Hill & Sullivan, 1928	Vertical faces	~~3~~ 2.414	-----)	.251	1.037	.197	3.897
64. United Verde Extension, 1928	Vertical sections	.676	1.894	.508	.474	.738	4.290

1/ Listed also in tables 5 and 6, under cut-and-fill stoping.

2/ Does not include \$0.852 covering unloading, yard maintenance, loading and shipping, teaming and trucking, building maintenance, heat, water, and lighting, given in Information Circular 6360.

3/ Development and stoping combined.

References: (59) I. C. 6311, (60) I. C. 6372, (61) I. C. 6290, (62) I. C. 6360, (63) I. C. 6407, (64) I. C. 6250, (56) I. C. 6377.

TABLE 8. - Mining costs at mines employing square-set stoping as the principal method

Designation and year	Costs per ton of ore hoisted						
	Labor and supervision	Compressed air, drills, and steel	Power	Explosives	Timber	Other supplies	Total
56. Ground Hog 1930	\$2.793	\$0.169	\$0.179	\$0.187	\$0.318	\$0.344	\$3.990
59. Argonaut, 1929	2.882	1/ .309	---	.159	.338	.303	3.991
60. Page, 1928	2.690	.280	.120	.240	.380	.110	3.820
61. Park Utah, 1928	3.062	.139	.191	.227	.493	.550	4.662
62. Tintic Standard, 1929	5.932	.770	.215	.224	.907	.584	8.632
63. Bunker Hill & Sullivan, 1928	1.934	.229	---	.167	.321	1.246	3.897

1/ Includes power.

Undercut Block Caving

In undercut block caving large blocks of ore are undercut and partly isolated from adjoining blocks of ore by boundary shrinkage stopes or by boundary drifts and raises, and the ore above the undercut area is allowed to cave under its own weight and that of the capping; the caved ore is drawn off from below, usually through a series of closely spaced finger raises into branched raises and main ore passes which lead to the haulage level. There are two principal variations of the method. In one variation the undercutting stopes consist of a series of parallel shrinkage stopes separated by narrow pillars and carried up for some distance above the undercutting level; the pillars are blasted out and drawn with the shrinkage ore, and the balance of the ore above the stopes caves and follows the broken ore down to the draw points. In the other variation the undercutting is accomplished by a series of parallel drifts or by a checkerboard system of drifts and crosscuts, with intervening pillars which are weakened later by drilling and blasting, so that they crush and allow the overlying block of ore to cave and break up as the ore is drawn off from below.

Table 9 presents costs at four mines employing the undercut block-caving method, distributed between development, stoping (undercutting), drawing, underground transportation, general underground expense, and surface and miscellaneous expense. In table 2 these costs are distributed between labor and supervision; compressed air, drills, and steel; power; explosives; timber; and other supplies.

1/ Includes power.

TABLE 9. - Mining costs at 4 mines employing undercut block caving

Designation and year	Variation of block caving	Costs per ton of ore hoisted						Total
		Develop- ment	Stoping (under- cutting)	Drawing	Under ground transportation	General under- ground	Surface and miscel- laneous	
65. Ray, 1928	Shrinkage undercut; caving to branched raises	\$0.1036	\$0.1165	\$0.1267	\$0.1106	\$0.0573	\$0.1619	\$0.6766
66. Inspiration, 1928	Undercut by drifts or connecting finger raises	.211	1/ (.208	----	.144	.012	.008	.583
67. Miami, Oct., 1925 to Sept., 1930 inc.	Undercut by drifts, caving to branch raises	.100	1/ (.136	----	.086	.057	.020	.399
68. Braden, 1928	Undercut by widening blasts above timbered drifts; ore drawn from chutes in these drifts	.046	1/ (.191	----	.091	.156	—	.484

1/ Undercutting and drawing combined.

References: (65) I. C. 6167, (66) I. C. 6169, (67) Trans. Am. Inst. Min. and Met. Eng., 1930, Year Book, pp. 39-86, (86) I. C. 6565.

TABLE 10. - Mining costs at 3 mines employing undercut block caving

Designation and year	Costs per ton of ore hoisted						Total
	Labor and super- vision	Compressed air, drills, and steel	Power	Explosives	Timber	Other supplies	
65. Ray, 1928	\$0.3714	\$0.0214	\$0.0351	\$0.0507	\$0.0563	\$0.1417	\$0.6766
66. Inspiration, 1928	.414	.024	.014	.036	.084	.011	.583
68. Braden, 1928	.1585	.0128	.0014	.0216	.0476	.0243	.2662
		(Plus general expense not distributed)					.2175
						Total	.4837

Sublevel Caving

In sublevel caving the ore body is mined on a series of sublevels, generally about 18 to 25 feet apart vertically, starting with the top level and working progressively downward. On any given sublevel, a series of timbered slice drifts (usually parallel) is driven from a line of raises (usually at right angles to the direction of the drifts), the slice drifts being separated by pillars of approximately the same width as the drifts. A back of ore is left between the backs of the drifts and the top of the ore at the floor of the sublevel above, and after the drifts have reached the boundary of the ore body, stoping limit, or an adjoining caved section the pillars and backs are mined back on the retreat toward the raises. This is done by starting at the inner end of the drift, blasting out both sides of the drift and over the top of the drift and weakening the back so that it caves to the capping or to the gob on the level above. The broken ore is loaded into cars and trammed to the raises or is scraped to the raises by power scrapers. The cave is drawn until an excessive amount of waste appears, when operations are moved back to the next drift set, and the process is continued until the pillars and backs have been drawn back to the chute line. As the sublevels are mined and caved the capping breaks and settles as the ore is removed from below. The method is intermediate between block caving and top slicing. Sublevel stoping and top slicing are described more clearly by sketches in an earlier circular.^{4/}

Dollar costs are available from only two mines employing sublevel caving and are presented in tables 11 and 12.

TABLE 11. - Mining Costs - sublevel caving

Designation and year	Costs per ton of ore hoisted					
	Develop- ment	Stoping	Underground transporta- tion	General under- ground	Surface applicable to under- ground	Total
69. Eureka- Asteroid, 1929	\$0.317	\$0.398	\$0.408 (Add timbering	\$0.135 .279 .414	----	\$1.537
70. Montreal, 1928	.194	.360	.344	.311	\$0.070	1.279

^{4/} Jackson, Chas. F., Mining by the Top-Slicing Method with Some Notes on Sublevel Caving: Inf. Circ. 6410, Bureau of Mines, 1931, 51 pp.
References: (69) I. C. 6348, (70) I. C. 6369.

TABLE 12. - Mining costs - sublevel caving

Designation and year	Costs per ton of ore hoisted						Total
	Labor and supervision	Compressed air, drills, and steel	Power	Explosives	Timber	Other supplies	
69. Eureka-Asteroid, 1929	\$0.927	\$0.134	\$0.143	\$0.128	\$0.068	\$0.137	\$1.537
70. Montreal, 1928	.808	.091	.150	.093	.060	.077	1.279

Top Slicing

In top slicing, the ore body is mined on a series of sublevels, generally about 8 to 15 feet apart vertically, starting with the top level and working progressively downward. On the top sublevel timbered slice drifts are driven, one alongside the other, without any intervening pillars, and are carried up to the capping. When the timbers begin to take excessive weight a floor is laid, and the timber either is blasted down or allowed to crush. The capping caves and fills the slice tightly. Then, starting on the next sublevel below, the operation is repeated, the slice drifts being carried up to the floor of the sublevel above. As mining continues on successively lower sublevels a mat of broken timber accumulates between the back of the active slices and the caved capping or overburden above. In this method all the ore is broken by drilling and blasting, and only the capping or overburden is broken by caving action.

Tables 13 and 14 present direct mining costs at mines employing top slicing.

Summary of Total Direct Mining Costs, by Types of Deposits

In this section tables are given in which costs are set up under the following captions: (1) Flat-lying beds; (2) tabular or lenticular deposits dipping at angles less than 45°, (3) tabular or lenticular deposits on dips greater than 45°, (4) large, irregular masses.

Table 17, Flat-lying beds, includes for the most part deposits ranging from 7 or 8 to 50 feet, though two are locally up to 100 feet or more thick. Portions of some deposits listed under type 2 are steeper than 45°, and parts of some of those in type 3 are flatter than 45°. There is necessarily some overlapping of types as tabulated, since at some mines more than one type of deposit is worked. The grouping in the tables therefore is somewhat arbitrary.

TABLE 13. - Mining costs: top slicing

Designation and year	Variation of top slicing	Costs per ton of ore hoisted					
		Develop-ment	Stoping	Underground transportation	General under-ground expense	Surface applic-able to under-ground	Total
71. Mesabi range mine 1928 ^{1/}	Parallel slices scraping into cars	(None).	\$0.729	\$0.128	\$0.250	\$0.058	\$1.165
72. Marquette No. 5 ^{1/} 1929	Parallel, scraping into chutes	\$0.052	.739	.210	.090	.004	1.095
73. Marquette No. 2 ^{1/} 1928	Radial slices scraping to chutes	.251	.707	.149	.193	.066	1.366
74. Miami, ^{2/} 1916	Top slicing in blocks, hand shovel-ing	.140	.550	.095	.065	.030	.880

^{1/} Costs per long ton of 2,240 pounds.^{2/} Costs per short ton of 2,000 pounds.

References: (71) I. C. 6325, (72) I. C. 6380, (73) I. C. 6179, (74) Trans. Am. Inst. Min. and Met. Eng., vol. 55, 1916, pp. 240-243.

TABLE 14. - Mining costs: top slicing

Designation and year	Costs per ton of ore hoisted						
	Labor and super-vision	Compressed air, drills, and steel	Power	Explosives	Timber	Other supplies	Total
71. Mesabi range mine ^{1/} 1928	\$0.709	\$0.026	\$0.092	\$0.061	\$0.144	\$0.133	\$1.165
72. Marquette No. 5, 1929 ^{1/}	.633	.100	.057	.062	.082	.161	1.095
73. Marquette No. 2, 1928 ^{1/}	.781	.092	.141	.093	.105	.154	1.366
74. Miami, 1916 ^{2/}	.528	.045	.064	.065	.130	.048	.880

^{1/} Costs per long ton of 2,240 pounds.^{2/} Costs per short ton of 2,000 pounds.

TABLE 15. - Costs at mines employing several stoping methods

Designation and year	Stoping methods	Costs per ton of ore hoisted					
		Develop- ment	Stoping	Transpor- tation, under- ground	General under- ground	Surface applic- able to under- ground	Total
75. Capote, 1929	Undercut caving, top slicing, cut-and-fill	\$0.058	\$0.894	\$0.201	\$0.083	\$0.242	\$1.478
76. Veta Grande, 1929	Square set- ting, top slicing, cut- and-fill	.323	1.529	.108	.122	.115	2.197
77. Pecos, 1927- 29	Cut-and-fill, square setting, shrinkage, and underhand pillars	.938	2.280	(All other costs,	1.161)		4.379

TABLE 16. - Costs at mines employing several stoping methods

Designation and year	Costs per ton of ore hoisted						
	Labor and super- vision	Compressed air, drills, and steel	Power	Explosives	Timber	Other supplies	Total
75. Capote, 1929	\$0.657	\$0.111	\$0.194	\$0.108	\$0.182	\$0.226	\$1.478
76. Veta Grande, 1929	1.139	.157	.066	.176	.441	.218	2.197

TABLE 17. - Mining costs in flat-lying beds

Designation and year	Stoping method	Costs per ton of ore hoisted					
		Develop- ment	Stoping	Transpor- tation, under- ground	General under- ground	Surface	Total
9. No. 8 Mine, S.E. Mo., 1928	Open stopping	\$0.045	\$0.483	\$0.222	\$0.135	----	\$0.885
10. Tri-State No. 1, 1928	do.	.049	.532	.217	.187	----	.985
11. Tri-State No. 2, 1928	do.	.050	.458	.200	.285	----	.993
12. Tri-State No. 3, 1928	do.	.030	.450	.165	.162	\$0.194	1.001
13. Waco, Tri- State, 1927- 28	do.	.050	.490	.155	.057	.033	.785
14. Barr, Tri- State, 1929	do.	.047	.497	.217	.069	.032	.862
15. Hartley- Grantham, 1929	do.	.000	.516	.196	.049	.020	.781
16. Hartley, 1932	do.	.000	.572	.152	.063	.041	.828
19. Mascot, 1929	Open stop- ing, mill hole sys- tem	.053	.222	.278	.086	----	.639
26. El Potosi, Aug., 1933	Open, un- der-hand stopes	.202	.337	.100	.067	.143	.849

TABLE 18. - Mining costs in flat-lying beds

Designation and year	Costs per ton of ore hoisted					Total
	Labor and super- vision	Compressed air, drills and steel	Power	Explosives	Other supplies	
9. No. 8 Mine, S. E. Mo. 1928	\$0.642	\$0.081	\$0.046	\$0.077	\$0.039	\$0.885
10. Tri-State No. 1, 1928	.624	.127	.041	.110	.083	.985
11. Tri-State No. 2, 1928	.576	.114	.076	.157	.070	.993
12. Tri-State No. 3, 1928	.675	.075	.102	.117	.032	1.001
13. Waco, -Tri- State, 1927-28	.536	---	.109	.072	.068	.785
14. Barr, 1929	.529	.066	.047	.103	.116	.862
15. Hartley- Grantham, 1929	.535	.052	.033	.107	.051	.781
16. Hartley, 1932	.507	.078	.060	.150	.033	.828
19. Mascot, 1929	.454	.047	.016	.060	.062	.639
26. El Potosi, Aug. 1933	.357	.035	.148	.082	.084	.706
		(Undistributed surface expense)				.143
				Total		.849

TABLE 19. - Mining costs for tabular or lenticular deposits, dipping less than 45°

Designation and year	Stoping method	Costs per ton of ore hoisted					
		Develop- ment	Stoping	Transpor- tation, under- ground	General under- ground	Surface	Total
1. Mineville, 1927 ^{1/}	Open stopping	\$0.103	\$0.416	\$0.705	\$0.026	----	\$1.250
17. Michigan Copper B, 1927	do.	.197	.600	.418	.057	\$0.022	1.294
18. Michigan Copper C, 1927	do.	.379	.500	.596	.075	.004	1.554
22. Rifle, Colo., 1931	do.	.200	1.350	.240	.090	.080	1.960
25. Presidio, Tex., 1929	do.	1.065	2.276	.533	---	.127	4.001
48. Teziutlan, Mex., 1930-31	Cut-and fill; some open stopes	.926	1.571	.269	.312	.160	3.238
58. Silver King Coalition, 1929	Stringer sets, stulls, and filling	2.086	3.502	1.848	.309	----	7.745
71. Mesabi range mine, 1928 ^{1/}	Top slicing	(None)	.729	.128	.250	.058	1.165

^{1/} Costs per long ton of 2,240 pounds, all others on short-ton basis.

TABLE 20. - Mining costs for tabular or lenticular deposits dipping less than 45° I.C. 6785

Designation and year	Costs per ton of ore hoisted						
	Labor and supervision	Compressed air, drills, and steel	Power	Explosives	Timber	Other supplies	Total
1. Mineville, 1927-1/	\$0.755	\$0.155	\$0.087	\$0.143	---	\$0.110	\$1.250
22. Rifle, Colo., 1921	1.290	.100	.150	.240	\$0.060	.120	1.960
25. Presidio, Tex. 1929	2.859	.597	.049	.294	.025	.177	4.001
48. Teziutlan, 1920-31	1.912	.387	.086	.335	.175	.343	3.238
58. Silver King Coalition, 1929	5.416	.854	.370	.486	.340	.277	7.747
71. Mesabi range mine, 1928	.709	.026	.092	.061	.144	.133	1.165

1/ Costs per long ton of 2,240 pounds, all others on short-ton basis.

TABLE 21. - Mining costs for tabular or lenticular deposits dipping over 45°

Designation and year	Stopping method	Costs per ton of ore hoisted					
		Develop- ment	Stopping	Under- ground transportation	General under- ground	Surface	Total
5. Hanover-Bessemer, 1929 ¹	Open, underhand benching	?	\$0.343	\$0.187	?	?	?
6. Burra Burra, 1928	Sublevel stopping	\$0.229	.332	.386	\$0.145	\$0.043	\$1.135
7. Mary, 1928	Open stope and pillars, underhand	.355	.545	2/.714	.154	.060	1.828
23. Granada, 1932	Simple, open stopes; no pillars	1.163	2.765	.974	.111	---	5.013
24. Sherritt-Gordon, 1931-32	Underhand benching, or subleveling with high lift	.327	.746	.341	----	---	1.304
27. Harmony, 1929	Shrinkage	.750	2.050	.210	.230	---	3.240
28. Nevada-Massachusetts, 1928	do.	.907	2.743	(included with development and stopping)	.105	---	3.755
29. Hillside, 1929	do.	.383	1.276	.399	.404	.138	2.600
30. Daisy, 1929	do.	1.165	1.395	.816	.340	.150	3.866
31. Cortez, 1929	do.	1.427	1.972	.467	----	---	3.866
32. Eighty-Five, 1930	do.	1.000	1.970	1.280	1.240	---	5.490
33. Verde Central, 1929-30	do.	?	1.661	.580	.111	.033	3.2385
34. Teck-Hughes, 1929	do.	.433	1.557	.443	.202	.435	3.070
35. Kirkland Lake Gold, 1930	do.	2.870	1.620	1.610	.140	.520	6.760
36. Elgoro, 1930	do.	1.298	1.610	.416	.443	.257	4.024

TABLE 21. - Mining costs for tabular or lenticular deposits dipping over 45°
(Continued)

Designation and year	Stoping method	Cost per ton of ore hoisted					
		Develop- ment	Stoping	Under- ground transportation	General under- ground	Surface	Total
37. Mogollon, 1922	Shrinkage	\$0.883	\$1.723	\$1.178	\$0.096	\$0.045	\$3.930
38. Sylvanite, 1930	do.	1.329	2.318	.641	.397	----	4.585
39. Engels, 1928	do.	.479	.760	.438	---	----	1.677
40. Mt. Hope, N. J., 1930 ¹	do.	.104	.632	.456	.111	.113	1.419
41. Vipond, 1930	do.	.728	1.275	.629	.148	----	2.780
44. Questa, 1929-30	Cut-and- fill, re- suing	6.10	5.51	(Included under development and stoping)			11.61
45. Cold Springs 1931 ⁴ /	do.	6.573	5.951	1.051	3.597	----	17.172
1931 ⁵ /	do.	1.010	.914	.161	.552	----	2.637
46. Lucky Tiger, 1924	Resuing, rills in wide ore	2.900	5.740	1.410	.720	.370	11.140
47. Matanambre, 1928	Cut-and- fill, some square setting	.711	1.267	.383	.184	.019	2.569
49. United East- ern, 1917- 25, inc.	Cut-and- fill	.518	~~6~~ 2.923	~~7~~ 1.275	.626	----	4.342
50. Champion, 1927	Horizontal cut-and- fill	.598	~~4~~ 1.755	~~7~~ 1.158	.180	.020	2.721
50. Champion 1930	Sublevel, inclined cut-and- fill	.489	1.162	.552	.207	.112	2.522
51. Pilares, 1929 ³ /	Cut-and- fill	.399	1.370	.370	.250	.211	2.600
53. Magna, 1928	Timbered rill, and rill and pillar	.736	2.849	.616	1.166	.130	5.497
54. Morning, 1928	Stringer-set cut-and-fill	.442	2.371	.530	.698	.204	4.245
55. Hecla, 1928	do.	.638	1.211	.322	.766	.360	3.297

TABLE 21. - Mining costs for tabular or lenticular deposits dipping over 45°
(Concluded)

Designation and year	Stopeing method	Cost per ton of ore hoisted					
		Develop- ment	Stopeing	Under- ground transportation	General under- ground	Surface	Total
56. Ground Hog, 1930	Inclined cut-and- fill, square sets	\$1.393	\$1.762	\$0.628	\$0.080	\$0.127	\$3.990
57. McIntyre, 1931	50 percent cut-and- fill; square sets and shrink- age	.655	1.489	.135	.660	.134	3.073
59. Argonaut, 1929	Square sets	.165	2.439	.519	.577	.291	3.991
60. Page, 1928	do.	1.170	2.150	.160	.180	.160	3.820
61. Park-Utah, 1928	do.	.828	2.426	.282	.583	.543	4.662
77. Pecos, 1927- 29	Cut-and- fill, square sets, shrinkage, underhand pillars	.938	2.280	(All other costs)		1.161	4.379

- 1/ Costs per long ton of 2,240 pounds. 2/ Includes hand-shoveling.
 3/ Includes stope development but not general development.
 4/ Based on tons of sorted ore hoisted. 5/ Based on tons of crude ore broken.
 6/ Includes tramming. 7/ Hoisting only. 8/ Some irregular, massive ore bodies.

TABLE 22. - Mining costs for tabular or lenticular deposits dipping over 45°

Designation and year	Costs per ton of ore hoisted						
	Labor and super- vision	Compressed air, drills, and steel	Power	Explo- sives	Timber	Other supplies	Total
6. Burra Burra, 1928	\$0.744	\$0.088	\$0.035	\$0.126	\$0.024	\$0.118	\$1.135
7. Mary, 1928	1.169	.231	.216	.142	----	.070	1.828
23. Granada, 1932	2.982	.730	.076	1.024	.059	.142	5.013
24. Smeritt- Gordon, 1931- 32	.685	.210	.015	.272	----	.122	1.304
27. Harmony, 1929	1.770	.300	.220	.360	.230	.360	3.240
28. Nevada-Massachu- setts, 1928	2.345	.125	.301	.455	.182	.347	3.755
29. Hillside, 1929	1.824	.144	.138	.301	.082	.111	2.600
30. Daisy, 1929	2.679	.352	.140	.370	.120	.205	3.866
31. Cortez, 1929	2.445	.430	.116	.495	.090	.290	3.866
34. Teck-Lugles, 1929	2.021	.152	.284	.407	.047	.159	3.070
35. Kirkland Lake Gold, 1930	4.160	.610	.390	.850	.450	.300	6.760
36. Elkoro, 1930	2.667	.189	.167	.355	.214	.432	4.024
37. Mogollon, 1922	2.365	----	.457	(All supplies)		1.108	3.930
38. Sylvanite, 1930	2.621	.721	.202	.733	.128	.180	4.585
39. Engels, 1928	1.098	.189	----	.267	.032	.091	1.677
40. Mt. Hope, W. J., 1930	.729	.227	.165	.141	.027	.130	1.419
41. Vipond, 1930	1.703	.378	.091	.331	.046	.231	2.780
44. Questa, 1929-30	8.980	(All materials and supplies)					2.630
45. Cold Springs, 1931	10.326	1.555	1.848	.806	1.172	.965	17.172
1931	1.663	.239	.284	.123	.180	.148	2.637
46. Lucky Tiger, 1924	6.937	.935	.668	.910	.953	.737	11.140
47. Matanabre, 1928	1.588	.161	.087	.200	.269	.264	2.569
49. United Eastern, 1917-25	2.611	(Included in other items)	.267	.513	.462	.302	4.175
				(Add miscellaneous)		...	.167
						Total	4.342
50. Champion, 1927	1.877	----	.191	(All supplies)		.653	2.721
1930	1.751	.197	.192	.172	.109	.101	2.522
51. Pilares, 1929	1.593	.231	.055	.232	.319	.170	2.600
53. Magna, 1928	2.654	.326	.197	.209	.532	.579	5.497
54. Morning, 1928	3.088	.122	.211	.158	.417	.249	4.245

TABLE 22. - Mining costs for tabular or lenticular deposits dipping over 45°
(Continued)

Designation and year	Costs per ton of ore hoisted						Total
	Labor and super- vision	Compressed air, drills, and steel	Power	Explo- sives	Timber	Other supplies	
55. Hecla, 1928	\$1.868	\$0.070	\$0.145	\$0.112	\$0.357	\$0.317	\$2.869
	(Plus development in waste, not segregated).....						.428
						Total	3.297
56. Ground Hog, 1930	2.793	.169	.179	.187	.318	.344	3.990
57. McIntyre, 1931	1.938	.052	.176	.309	.240	.358	3.073
59. Argonaut, 1929	2.882	7/.309	---	.159	.338	.303	3.911
60. Page, 1928	2,690	.280	.120	.240	.380	.110	3.820
61. Park-Utah, 1928	3.062	.139	.191	.227	.490	.550	4.662

1/ Distribution estimated from original paper.

2/ Cost per long ton of 2,240 pounds.

3/ Based on tons of sorted ore hoisted.

4/ Based on tons of crude ore broken.

5/ Some irregular, massive ore bodies.

6/ Except development in waste.

7/ Includes power.

TABLE 23. - Mining costs for large, irregular masses

Designation and year	Stoping method	Costs per ton of ore hoisted					Total
		Develop- ment	Stoping	Transportation under- ground	General under- ground	Surface	
2. Marquette No. 1, 1928 1/	Open stopping	\$0.218	\$0.770	\$0.244	\$0.180	---	\$1.412
3. Marquette No. 2, 1928 1/	Sublevel stopping	.251	.707	.149	.193	\$0.066	1.366
4. Manominee No. 1, 1928 1/	do.	.211	.467	.173	.052	.027	.930
8. Ducktown No. 3, 1928	Open, under- hand stopes	.302	.271	2/.366	.076	.015	1.030
20. Montreal, 1928 1/	Sublevel stopping	.461	.255	.278	.106	.060	1.150
70. Do. 1/	Sublevel caving	.194	.360	.344	.311	.070	1.279
21. Spring Hill, 1929-30	Modified sublevel stopping	.377	1.072	.131	.218	.147	1.945
42. Beatson, 1922-26	Modified shrinkage	4/.290	.366	.137	---	---	.793

TABLE 23. - Mining costs for large, irregular masses
(Continued)

Designation and year	Stoping method	Costs per ton of ore hoisted					
		Develop- ment	Stoping	Transpor- tation under- ground	General under- ground	Surface	Total
43. Alaska- Juneau, 1928	do. <u>5</u> /	\$0.061	\$0.122	\$0.114	-----	-----	\$0.297
52. La Colorada, 1929	Cut-and-fill	.561	1.203	.166	\$0.278	\$0.233	2.441
62. Tintic Stand- ard, 1929	Square setting	1.143	4.973	1.056	.424	1.036	8.632
63. Punker Hill & Sullivan, 1928	do.	<u>2</u> (2.414	---)	.251	1.037	.197	3.897
64. United Verde Extension, 1928	do.	.676	1.894	.508	.474	.738	4.290
65. Ray, 1928	Block caving	1.036	.2432	.1106	.0573	.1619	0.6766
66. Inspiration, 1928	do.	.211	.208	.144	.012	.008	.583
67. Miami, Oct. 1925 to Sept. 1930	do.	.100	.136	.086	.057	.020	.399
74. Miami, 1916	Top slicing	.140	.550	.095	.065	.030	.880
68. Braden, 1928	Block caving	.046	.191	.091	.156	-----	.484
69. Eureka- Asteroid, 1929	Sublevel caving	.317 (Add timbering)	.398	.408	.135 .279 .414	----- ----- -----	----- 1.537
72. Marquette No. 5, 1929 <u>1</u> /	Top slicing	.052	.739	.210	.090	.004	1.095
73. Marquette No. 2, 1928 <u>1</u> /	do.	.251	.707	.149	.193	.066	1.366
75. Capote, 1929	Undercut caving, top slicing, cut- and-fill	.058	.894	.201	.083	.242	1.478
76. Veta Grande, 1929	Square setting, top slicing, cut-and-fill	.323	1.529	.108	.122	.115	2.197

- 1/ Costs per long ton of 2,240 pounds, all other costs on short ton basis.
2/ Includes hand shoveling.
3/ Large rounds drilled from mining raises.
4/ Includes \$0.237 stope preparation and development.
5/ Large blasts in coyote drifts driven from mining raises.
6/ 54 percent by cut-and-fill stoping, 12 percent by square setting, 14 percent by shrinkage stoping, 20 percent development ore. Costs do not include superintendence, engineering, sampling, time office, and watchmen.
7/ Development and stoping combined.

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TABLE 24. - Mining costs for large, irregular masses

Designation and year	Costs per ton of ore hoisted						Total
	Labor and super- vision	Compressed air, drills, and steel	Power	Explo- sives	Timber	Other supplies	
2. Marquette No. 1, 1928 ^{1/}	\$0.893	\$0.153	\$0.108	\$0.136	\$0.013	\$0.109	\$1.412
3. Marquette No. 2, 1928 ^{1/}	.781	.092	.141	.093	.105	.154	1.366
4. Menominee No. 1, 1928 ^{1/}	.562	.111	.070	.129	.019	.039	.930
8. Ducktown No. 3, 1928	.675	.090	.051	.111	None	.103	1.030
20. Montreal, 1928 ^{1/}	.698	.107	.106	.136	.043	.070	1.160
70. do. 1/ 21. Spring Hill, 1929-30	.808 1.415	.091 .183	.150 .003	.093 .267	.060 .010	.077 .067	1.279 1.945
42. Beatson, 1922-26	.347	.119	----	.140	----	.187	.793
43. Alaska- Juneau, 1928	.1803	----	.0089	.0594	----	.0480	.2966
52. La Colorado, 1929	1.273	.235	.070	.278	.257	.328	2.441
62. Tintio Standard, 1929	5.932	.770	.215	.224	.907	.584	8.632
63. Bunker Hill & Sullivan, 1928	1.934	^{2/} .229	----	.167	.321	1.246	3.897
65. Ray, 1928	.3714	.0214	.0351	.0507	.0563	.1417	.6766
66. Inspiration, 1928	.414	.024	.014	.036	.084	.011	.583
74. Miami, 1916	.528	.045	.064	.065	.130	.048	.880
68. Braden, 1928	.1585	.0128	.0014	.0216	.0476	.0243	.2662
69. Eureka-Asteroid.	.927	.134	.143	.128	.068	.137	1.537
72. Marquette No. 5, 1929 ^{1/}	.633	.100	.057	.062	.082	.161	1.095
73. Marquette No. 2, 1928 ^{1/}	.781	.092	.141	.093	.105	.154	1.366
75. Capote, 1929	.657	.111	.194	.108	.182	.226	1.478
76. Veta Grande, 1929	1.139	.157	.066	.176	.441	.218	2.197

^{1/} Cost. per long ton of 2,240 pounds.^{2/} Includes power.

COSTS IN UNITS OF MAN-HOURS, EXPLOSIVES, TIMBER,
AND POWER

Direct costs in units of man-hours, explosives, timber, and power, are presented in the following tables. The various mines are designated by the same numbers as in the preceding tables and grouped according to the principal stoping method employed. By turning back to tables 1 to 16, the reader will find references to the original articles from which the data in the following tables were taken. In addition to the mines listed in tables 1 to 24 the following tables will include data from a number of other mines, references to which will be carried in the footnotes.

Tons per man-shift may be computed by taking the reciprocal of the man-hours per ton, and multiplying by the length of the shift, that is 8.

The figures in tables 25 to 31 cover labor for stoping and development combined.

TABLE 25. - Mining costs, open-stope mines, man-hours

Designation	Stoping method	Man-hours per ton of ore hoisted						Total
		Breaking (drill- ing and blasting)	Timber- ing	Shovel- ing	Haulage and hoist- ing	General under- ground	Surface	
1. Mineville, N. Y. 1/	Irregular pillars	0.264	----	0.526	0.193	0.090	----	2/.073
2. Marquette No. 11/	Regular stope and pillar	.454	0.073	.370	.237	.179	----	2/.313
3. Marquette No. 21/	Sublevel stop- ing and top slicing	.086	.316	.208	.217	.202	----	2/.029
4. Menominee No. 11/	Sublevel stop- ing	.441	.048	.012	.178	.106	----	2/.785
6. Burra Burra	do.	.485	----	.363	.205	.189	0.074	1.316
7. Mary	Open, under- hand stoping	.649	None	3/.738	Hoisting .528	.318	.632	2.865
8. Ducktown No. 3	do.	.301	None	3/.562	.232	.149	----	2/.244
9. No. 8 Mine, S.E. Miss. ouri	Irregular Pillars	.122	None	.319	.264	.170	----	2/.875
10. Tri-State No. 1	do.	.377	None	.407	.282	.275	----	2/.341
11. Tri-State No. 2	do.	.297	None	.345	.125	.109	----	2/.876
12. Tri-State No. 3	do.	.139	None	.262	.366	.069	.069	.905

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TABLE 25. - Mining costs, open-stope mines, man-hours
(Continued)

Designation	Stoping method	Man-hours per ton of ore hoisted						
		Breaking (drill- ing and blasting)	Timber- ing	Shovel- ing	Haulage and hoist- ing	General under- ground	Surface	Total
13. Waco, Tri- State	Irregular Pillars	0.280	None	0.355	0.367	0.039	-----	<u>2</u> 1.041
14. Barr, Tri- State	do.	.223	None	.279	.305	.081	0.041	.929
15. Hartley- Grantham	do.	.218	None	.272	.220	.035	.026	.771
16. Hartley	do.	.229	None	.198	.080	.166	.040	.713
19. Mascot	Open stoping, mill-hole system	.214	0.009	.093	.368	.147	-----	<u>2</u> /.831
20. Montreat ^{1/}	Sublevel stopping	.347	.133	.114	.321	.122	.092	1.129
21. Spring Hill	Modified sub- level stopping	1.226	None	.105	.163	.219	.191	1.904
22. Rifle, Colo.	Regular pillars	.330	.240	1.000	.280	.020	-----	<u>2</u> 1.870
23. Granada	No pillars	1.557	.402	.926	1.297	.354	-----	<u>2</u> 4.536
25. Presidio	Irregular pillars	1.690	-----	1.980	1.370	.730	.448	6.218
26. El Potosi	Open, under- hand stoping	1.647	.036	Includ- ed with break- ing	.161	.077	1.170	3.091

^{1/} Per long ton of 2,240 pounds.^{2/} Underground labor only.^{3/} Includes hand tramping.TABLE 26. - Mining costs, shrinkage-stoping mines, man-hours

Designation	Variation of stopping method	Man-hours per ton of ore hoisted						
		Breaking (drill- ing and blasting)	Timber- ing	Shovel- ing	Haulage and hoist- ing	General under- ground	Surface	Total
27. Harmony	On drift pillars	1.190	-----	0.060	0.040	0.570	-----	<u>1</u> 1.860
28. Nevada- Massachu- setts	do.	.883	0.429	<u>2</u> /.550	<u>3</u> /.688	.501	0.142	3.193

TABLE 26. - Mining costs, shrinkage-stoping mines, man-hours
(Continued)

Designation	Variation of stopping method	Man-hours per ton of ore hoisted						
		Breaking (drill- ing and blasting)	Timber- ing	Shovel- ing	Haulage and hoist- ing	General under- ground	Surface	Total
29. Hillside	On pillars or stulls	1.226	0.278	1.022	Includ- ed with shovel- ing	0.204	----	<u>1</u> 2.730
30. Drisy	On stulls	1.600	.250	.250	1.600	.300	0.177	4.177
31. Cortez	On drift pillars	1.409	.282	1.030	.531	.110	----	<u>1</u> 3.362
33. Verde- Central ⁴	On stulls	.720	.330	----	.610	.210	----	<u>4</u> 1.870
34. Tack- Hughes	On drift pillars	1.325	.117	.646	Includ- ed with shovel- ing	.409	.909	3.406
35. Kirkland Lake Gold	On drift timbers	2.060	.530	1.560	1.580	1.100	----	<u>1</u> 6.830
36. Elkroro	On stulls	.555	.818	----	.577	.170	.117	2.237
37. Mogollon	On drift pillars	.740	(All other underground)			3.610	2.310	6.660
38. Sylvanite	On stulls	1.700	(All other underground)			1.110	----	<u>1</u> 2.810
39. Engels	On drift pillars	.642	.099	.266	.381	.074	.073	1.535
40. Mt. Hope, N. J.	On drift and slope pillars	.336	.045	.062	.418	.268	.076	1.205
41. Vipond	On stulls or drift pillars	1.398	Includ- ed with break- ing	.212	.970	.256	----	<u>1</u> 2.826
43. Alaska- Juneau	Coyote blast- ing from min- ing raises	.095	----	----	.064	----	.107	.266
A. Climax ⁵ / Molybdenum 1929	Shrinkage stopping with pillar caving	.517	Includ- ed with break- ing	----	.092	----	----	<u>1</u> /.609
B. Michigan ⁶ / iron mine	do.	.545	do.	----	.357	.046	----	<u>1</u> /.748

1/ Underground labor only.

2/ Includes tramming.

3/ Hoisting only.
included

4/ Stopping only, development not
included

5/ Special communication. 6/ Special communication; costs per long ton of 2,240
pounds.

TABLE 27. - Mining costs, cut-and-fill stoping mines, man-hours

Designation	Variation of stoping method	Man-hours per ton of ore hoisted							
		Breaking (drill- ing and blasting)	Timber- ing	Shovel- ing	Haulage and hoist- ing	General under- ground	Surface	Total	
44. Questa Molybden- um	Horizontal, largely resuing	-----	-----	-----	-----	-----	-----	5.263	
45. Cold Springs ^{1/} Do. ^{3/}	Resuing do.	5.070 .471	^{2/} 3.840 ^{2/} .589	1.540 .236	2.630 .404	4.990 .768	1.920 .295	17.990 2.763	
46. Lucky Tiger	Resuing; rills in wide ore	-----	-----	-----	-----	-----	-----	12.500	
47. Mata- hambre	Horizontal	1.070	.780	1.430	.640	.390	.038	4.348	
50. Champion 1930	Sublevel, inclined	.730	.300	^{4/} .920	.860	.230	.123	3.163	
52. La Color- ada	Horizontal ^{5/}	.876	.799	.990	.494	.460	.740	4.359	
53. Magma	Timbered rill and rill-and- pillar	2.208	(Included with breaking)		.639	1.413	1.234	5.494	
54. Morning	Stringer-set and-fill	.514	1.740	.583	.419	.906	-----	^{6/} 4.162	
55. Hecla	do.	.313	.606	.343	.381	.387	-----	^{6/} 2.030	
56. Ground Hog	Inclined and square set- ting	3.468	(Included with breaking)		1.005	.285	1.945	6.703	
57. McIntyre	Horizontal ^{7/}	1.380	.130	included with breaking		.310	.530	.267	2.617
58. Silver King Co- alition	Stringer sets, stulls, and filling	1.643	.899	^{8/} 2.918	2.239	.356	-----	8.055	
C. Block P ^{9/}	Horizontal, some resu- ing	1.751	.556	1.932	.655	.456	.469	5.819	
D. United Verde ^{10/}	64% cut-and- fill; 27% square set; 8% top slicing; 1% shrinkage	.381	.532	.762	.238	1.164	-----	3.077	

1/ Based on tons of sorted ore hoisted. 2/ Sorting. 3/ Based on tons of crude ore broken. 4/ Includes sorting. 5/ 54% cut-and-fill, 12% square-setting, 14% shrinkage stoping, 20% development ore. 6/ Underground labor only. 7/ 50% horizontal cut-and-fill, balance shrinkage and square-set stoping. 8/ Includes sorting. 9/ I. C. 6416. 10/ I. C. 6440.

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TABLE 28. - Mining costs, square-set stoping mines, man-hours

Designation	Variation of square-set method	Man-hours per ton of ore hoisted						Total
		Breaking (drilling and blasting)	Timbering and filling	Shovel-ing	Haulage and hoisting	General under-ground	Surface	
59. Argonaut	Horizontal floors	<u>1/</u> 2.350	<u>2/</u> 0.347	0.475	0.514	0.482	---	<u>3/</u> 4.168
60. Page	do.	2.222	included with breaking		.267	.269	---	<u>3/</u> 2.758
61. Park-Utah	Inclined backs or rills	.980	.930	.300	.330	.650	0.448	3.938
62. Tintic Standard	Vertical sections	1.078	2.562	1.544	.693	1.345	1.141	8.366
64. United Verde Extension	do.	---	---	---	---	---	---	<u>3/</u> 3.239
56. Ground Hog	Inclined backs, both square-setting and cut-and-fill	3.468	included with breaking		1.005	.285	1.945	6.703
E. Black Rock ^{4/}	Vertical sections; overhand and underhand	.940	1.170	.740	.870	1.018	1.481	6.219
F. Central Eureka ^{5/}	Horizontal	2.476	included with breaking	.270	1.129	.069	.594	4.538

1/ Includes timbering. 2/ Waste breaking and filling only. 3/ Underground labor only. 4/ I.C. 6370. 5/ I.C. 6512.

TABLE 29. - Mining costs, undercut block caving, man-hours

Designation	Man-hour per ton of ore produced		
	Stoping	Total underground	Total payroll
65. Ray, 1927	0.079	0.750	0.852
1928	.069	.659	.738
67. Miami	---	.296	---
68. Braden, 1927	---	.606	.870
1928	---	.656	.919

TABLE 30. - Mining costs, sublevel caving, man-hours

Designation	Man-hours per ton of ore hoisted ^{1/}						Total
	Breaking (drilling and blast- ing	Timbering	Shoveling	Haulage and hoisting	General under- ground	Surface	
69. Eureka- Asteroid	0.453	0.070	0.218	0.406	0.250	0.409	1.806
70. Montreal	.257	.377	.124	.354	.116	.108	1.336
G. Iron mine, Minnesota ^{2/}	.763	included with breaking		.169	.261	---	<u>3/</u> 1.193
H. Iron mine, Michigan	.565	do.		.214	.192	---	<u>3/</u> .971
I. Iron mine, Cuyuna range			Total underground		.879	.156	1.035
J. Iron mine, Marquette range			Total underground		1.204	.574	1.778
K. Iron mine, Gogebic range			Total underground		.730	.457	1.187
L. Do.			Total underground		.550	.213	.763

^{1/} Iron mines; man-hours per long ton of 2,240 pounds.

^{2/} Sublevel caving and some top slicing.

^{3/} Underground labor only.

TABLE 31. - Costs, top-slicing mines, man-hours

Designation	Variation of top-slicing	Man-hours per ton of ore hoisted ^{1/}						Total
		Breaking (drilling and blasting)	Timbering	Shoveling	Haulage and hoisting	General underground	Surface	
71. Mesabi range mine	Parallel; slices, scraping to cars	0.090	0.276	0.359	0.184	0.210	0.055	1.174
72. Marquette No. 5	Parallel; scraping into chutes	.104	.307	.183	.172	.137	.219	1.122
M. Iron mine, Mesabi range	Parallel; scraping to cars	.715	Included with breaking		.260	.179	---	^{2/} 1.154
N. do.	do.	.585	do.		.086	.060	---	^{2/} .731
O. do.	do.	.540	do.		.082	.155	---	^{2/} .777
P. do.	Radial; scraping to chutes	.721	do.		.252	.154	---	^{2/} 1.127
Q. Iron mine, Vermilion range	do.	.501	do.		.314	.448	---	^{2/} 1.263
R. Iron mine, Cuyuna range	do.	.569	do.		.193	.210	---	^{2/} .972
S. Iron mine, Marquette range	Parallel; scraping to chutes	.722	do.		.222	.074	---	^{2/} 1.018

^{1/} Iron mines; man-hours per long ton of 2,240 pounds.^{2/} Underground labor only.

TABLE 32. - Explosives, timber, and power consumption, open-stope mines

Designation	Stopping method	Explo- sives pounds	Units per ton of ore hoisted					Total
			Bd. ft.	Timber	Power, kw.-hr.			
				Round timber lin. ft. $\frac{1}{2}$	Com- pressed air	Hoist- ing and haulage	Other	
1. Mineville, E. Y. 2/	Irregular pillars	0.937	---	---	5.16	5.49	0.26	10.91
2. Marquette No. 12/	Regular stope-and- pillar	.901	0.445	---	4.33	2.80	4.43	11.56
3. Marquette No. 22/	Sublevel stoping and top slicing	.473	---	0.55	4.24	3.24	1.91	9.39
4. Menominee No. 12/	Sublevel stoping	.826	---	.03	5.90	3.64	2.26	11.80
5. Hanover- Bessemer 2/	Underhand benching to inclined stope raises	.530	---	---	2.91	---	4.00	6.91
6. Burra Burra	Sublevel stoping	.755	.610	---	---	---	---	7.92
7. Mary	Open, underhand stoping	.782	---	---	8.75	81.10 lbs. coal	1.75	10.50
8. Ducktown No. 3	do.	.654	---	---	---	---	---	6.42
9. No. 8 Mine, S. E. Mis- souri	Irregular pillars	.634	---	---	---	---	---	---
10. Tri-State No. 1	do.	.750	---	---	6.00	3.69	.22	9.91
11. Tri-State No. 2	do.	1.265	---	---	2.51	2.42	.82	5.75
12. Tri-State No. 3	do.	.875	---	---	1.40	2.77	---	4.17
13. Waco, Tri-State	do.	.594	---	---	---	---	---	6.65
14. Barr, Tri-State	do.	.805	---	---	2.16	2.79	1.14	6.09
15. Hartley- Grantham	do.	.741	---	---	31.78 cu. ft. of gas	1.85	.04	1.89
16. Hartley	do.	1.120	---	---	1.82	1.30	1.12	4.24
17. Michigan Copper B.	Large stopes and pillars	4.800	1.65	---	---	---	---	2.66+ 205 lbs. coal

TABLE 32. - Explosives, timber, and power consumption, open-stope mines (Cont'd.)

Designation	Stoping method	Explosives pounds	Units per ton of ore hoisted					
			Timber		Power, kw.-hr.			
			Ed. ft.	Round timber lin. ft. 1/	Compressed air	Hoisting and haulage	Other	Total
18. Michigan Copper C.	Long narrow stopes and pillars	3.180	18.73	---	---	---	---	8.67+ 206 lbs. coal
19. Mascot	Mill-hole system, irregular pillars	.502	---	---	3.81	1.69	4.18	9.68
20. Montreal ^{2/}	Sublevel stoping	.850	1.65	---	4.60	5.19	2.82	12.61
21. Spring Hill	Modified sublevel stoping	1.262	.38	---	---	---	---	10.43
22. Rifle, Colo.	Regular pillars	1.150	---	---	---	---	---	0.75
23. Granada	No pillars	5.087	2.48	---	29.90	4.08	1.42	35.40
25. Presidio	Irregular pillars	2.000	---	---	14.83	2.38	.56	17.77
26. El Potosi	Open, underhand stoping	.603	---	---	3.61	3.71	10.08	17.40

^{1/} Includes lagging.^{2/} Per long ton of 2,240 pounds. All others on short-ton basis.

TABLE 33. - Explosives, timber, and power consumption, shrinkage-stopping mines

Designation	Variation of shrinkage method	Units per ton of ore hoisted						
		Explosives, pounds	Timber		Power, kw.-hr.			
			Rd. ft.	Round timber lin. ft. ^{1/}	Compressed air	Hoisting and haulage	Other	Total
27. Harmony	On drift pillars	2.050	---	---	---	---	---	10.10
28. Nevada-Massachusetts	do.	1.739	3.63	0.61	---	---	---	10.48
29. Hillside	On pillars or on stulls	1.800	---	1.50	4.90	1.20	4.30	10.40
30. Daisy	On stulls	2.500	6.00	---	9.00	6.20	9.50	24.70
31. Cortez	On drift pillars	3.300	2.27	---	21.18	10.30	.29	31.77
33. Verde Central ^{2/}	On stulls	1.160	3.08	---	8.86	4.50	3.00	16.44
34. Teck-Hughes	On drift pillars	2.360	3.52	---	13.55	5.10	.91	19.56
35. Kirkland Lake Gold	On drift timbers	4.720	4.23	---	---	---	---	84.60
36. Elkoro	On stulls	1.239	1.36	.85	8.48	1.95	.59	10.92
37. Mogollon	On drift pillars	2.620	---	---	---	---	---	37.80
38. Sylvanite	On stulls	2.270	---	.864	---	---	---	---
39. Engels	On drift pillars	1.379	1.231	.074	---	---	---	9.64
40. Mt. Hope, N. J.	On drift and slope pillars	1.147	---	---	6.14	4.42	2.77	13.33
41. Vipond	On stulls or drift pillars	1.780	.42	.70	18.90	4.60	4.50	28.00
43. Alaska-Juneau	Coyote blasting from mining raises	.400	---	---	---	---	---	1.61
A. Climax Molybdenum 1929	Shrinkage stopping with pillar caving	.521	---	---	2.43	1.62	---	4.05
B. Michigan ^{3/} iron mine	do.	.630	4.08	.68	2.95	.48	2.05	5.48

^{1/} Includes lagging.^{2/} Stopping only, development not included.^{3/} Per long ton of 2,240 pounds.

TABLE 34. - Explosives, timber, and power consumption, cut-and-fill stoping mines

Designation	Variation of cut-and-fill stoping	Units per ton of ore hoisted						
		Explosives pounds	Timber		Power, kw.-hr.			
			Ed. ft.	Round timber lin. ft. ^{1/}	Compressed air	Hoisting and haulage	Other	Total
44. Questa Molybdenum	Horizontal, largely resuing	2.93	---	4.86	16.98	---	---	---
45. Cold Springs ^{2/} Do. ^{3/}	Resuing do.	4.48 .69	4.40 .67	42.30 6.50	29.30 4.50	12.30 1.90	20.00 3.10	61.60 9.50
47. Matachambre	Horizontal	1.02	1.145	6.148 pieces	3.00	3.00	3.01	14.01
50. Champion	Sublevel, inclined	1.30	4.30	---	12.40	4.00	5.30	21.70
52. La Colorada	Horizontal ^{4/}	1.37	7.19	---	6.05	4.36	.88	11.29
53. Magna	Timbered rill, and rill-and-pillar	.90	19.00	---	14.17	8.92	11.52	34.61
54. Morning	Stringer-set-and-fill	.964	12.75	---	28.82	4.35	6.20	39.37
55. Hecla	do.	.783	11.21	1.23	10.96	4.35	1.70	17.01
56. Ground Hog	Inclined, and square-setting	.900	2.97	---	---	---	---	8.75
57. McIntyre	Horizontal ^{5/}	1.090	---	---	9.84	8.02	1.56	19.42
58. Silver King Coalition	Stringer sets, stulls and filling	3.607	---	---	---	---	---	77.70
C. Block P.	Horizontal; some resuing	2.854	3.96	7.54	9.97	5.56	1.93	17.46
D. United Verde	64% cut-and-fill, 27% square set, 8% top slicing, 1% shrinkage	1.028	9.47	---	10.15	2.35	3.94	16.44

1/ Includes lagging.

2/ Based on tons of sorted ore hoisted.

3/ Based on tons of crude ore broken.

4/ 54% cut-and-fill; 12% square setting; 14% shrinkage stoping; 20% development ore.

5/ 50% cut-and-fill; balance shrinkage and square-set stoping.

TABLE 35. - Explosives, timber, and power consumption, square-set stoping mines

Designation	Variation of square-set method	Units per ton of ore hoisted						
		Explosives, pounds	Timber		Power, kw.-hr.			
			Bd. ft.	Lin. ft. ¹ /	Compressed air	Hoisting and haulage	Other	Total
59. Argonaut	Horizontal floors	1.010	7.05	1.08	9.02	9.90	14.16	33.08
60. Page	do.	1.405	13.09	---	9.42	2.73	2.92	15.07
61. Park-Utah	Inclined backs or rills	1.530	16.46	---	6.68	6.94	15.61	29.23
62. Tintic Standard	Vertical sections	1.068	25.51	---	14.90	15.40	16.30	46.60
64. United Verde Extension	do.	2/.390	16.82	---				
56. Ground Hog	Inclined, square setting and cut-and-fill	.900	2.97	---	---	---	---	8.75
E. Black Rock	Vertical sections; overhand and underhand	1.730	12.00	2.800	29.80	10.30	13.60	53.70
F. Central Eureka	Horizontal	1.010	(25.78 ³ /)		---	---	---	86.00

¹/ Includes lagging. ²/ Stopping only. ³/ Round timber, calculated to board feet.

TABLE 36. - Explosives, timber, and power consumption, undercut block-caving mines

Designation	Variation of block caving	Units per ton of ore hoisted						
		Explosives, pound	Timber		Power, kw.-hr.			
			Bd. ft.	Lin. ft.	Compressed air	Hoisting and haulage	Other	Total
65. Ray, 1927	Shrinkage undercut	0.252	1.79	---	---	---	---	---
1928	do.	.319	1.88	---	---	---	---	---
67. Miami	Undercut by drifts and crosscuts	.222	1.045	---	---	---	---	1.90
68. Braden	Undercut by widening blasts above timbered drifts	.116	1.080	---	1.86	.49	.56	2.91

TABLE 37. - Explosives, timber, and power consumption, sublevel-caving mines

Designation	Units per long ton of ore hoisted						
	Explosives, pound	Timber		Power, kw.-hr.			
		Board feet	Lin. ft. and cords of lagging	Compressed air	Hoisting and haulage	Other	Total
69. Eureka- Asteroid	0.710	3.35	---	5.63	5.32	4.67	15.62
70. Montreal	.590	2.76	---	3.31	1.13 plus 0.32 pound coal	1.80	6.24
G. Iron mine, Michigan	.421	1.551	0.0013 cd.	---	---	---	---
H. Do.	.722	---	----	4.66	3.34	1.38	9.38

TABLE 38. - Explosives, timber, and power consumption, top-slicing mines

Designation	Variation of top slicing	Units per long ton of ore hoisted						
		Explo-sives, pound	Timber		Power, kw.-hr.			
			Bd. ft.	Lin. ft. or cords of lagging	Com-pressed air	Hoist-ing and haulage	Other	Total
71. Mesabi range mine	Parallel slices, scraping to cars	0.395	2.83	?	---	---	---	4.47
72. Marquette No. 5	Parallel, scraping to chutes	.408	.67	?	4.49	3.38	4.62	12.49
M. Iron mine, Mesabi range	Parallel, scraping to cars	.801	?	?	1.44	1.06	.47	2.97
N. Do.	do.	.694		2.40 .0012 cds.	.78	.78	.30	1.86
O. Do.	do.	.403	1.06	1.256 .0012 cds.	1.28	.84	1.37	3.49
P. Do.	Radial scraping to chutes	.562	---	2.21 .0032 cds.	1.78	1.41	.97	4.16
Q. Iron mine, Vermilion range	do.	.433	---	---	1.78	2.89	.67	5.25
R. Iron mine, Cuyuna range	do.	.634	---	.846	2.47	1.34	7.70	11.51
S. Iron mine, Marquette range	Parallel scraping to chutes	.365	1.376	3.052	7.57	5.37	3.47	16.41